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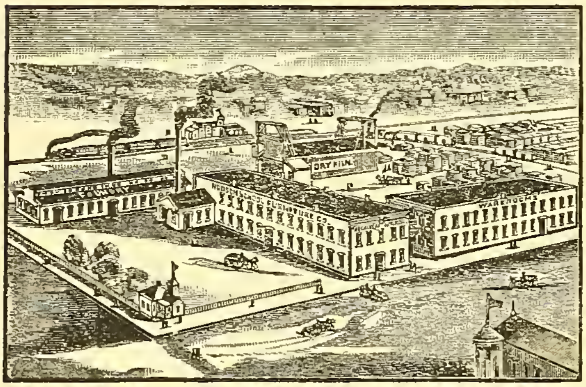

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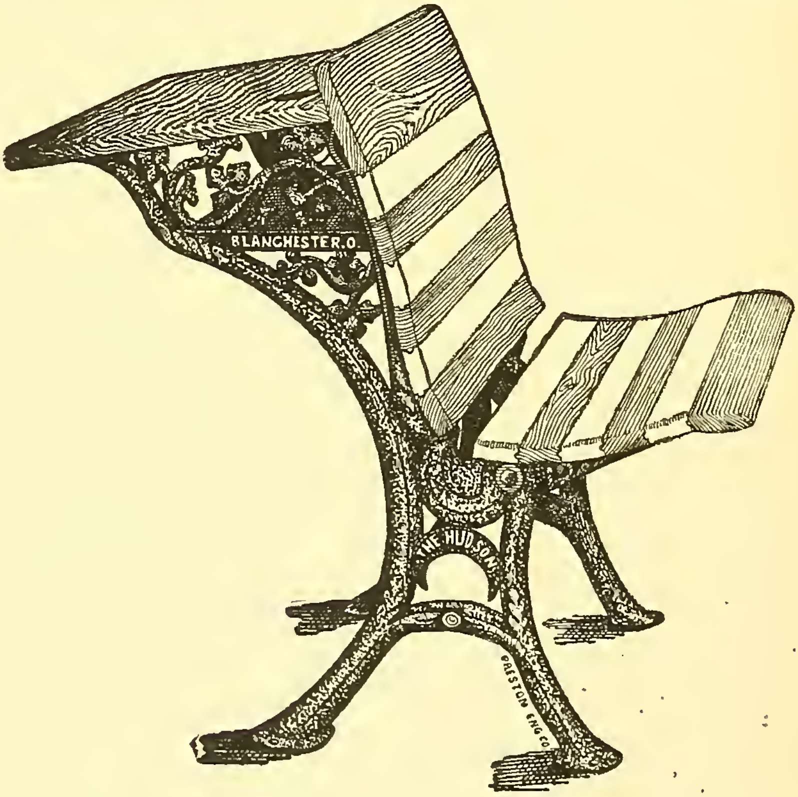

The Hudson School Furniture Co.,

ATHENS, OHIO.

OHIO UNIVERSITY BULLETIN.

VOLUME II. ATHENS, O., DECEMBER, 1894. NUMBER 2.

The BULLETIN is issued four times a year, and is under the supervision of the Faculty of the University. Each number will contain from twelve to sixteen pages. The price is fifty cents per annum, or ten cents for single numbers. All remittances and communications should be addressed, UNIVERSITY BULLETIN, Athens, Ohio.

Entered at the Post Office at Athens, Ohio as second class matter—1894.

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PRACTICAL TRIUMPHS OF BIOLOGY.

HENRY E. CHAPIN.

The recent article in *McClure's Magazine* for September, on "Foods in the Year 2000," has, doubtless, while being received with much incredulity, astounded the laity for its very boldness. If such things are possible, what may we not be led to hope? May not the chemist yet solve the problem of life?

It is, indeed, true that many attempts have been made to study life chemically, but the very essential of life, viz., protoplasm has not yet been analyzed, and probably never will be. If the chemical laboratory is not yielding anything of real value in our search after life, to whom, then, shall we turn? Naturally to the *biologist.* But here, again, we are doomed to disappointment; for, though elaborate theories have been established regarding the true origin and nature of life, the biologist knows as little about the matter as his co-worker in science. We may set up theories, and our own may be the correct one—but it must remain a theory. This, biologists have come to recognize, and that their time can best be spent in other directions. Certainly, in these utilitarian times there is great incentive to work for the highest good to mankind.

It matters little, after all, whether Haeckel with his radical views of creation, Darwin with his "survival of the fittest," Agassiz with his more orthodox proposition, or Weissmann with his "germplasm" attracts to himself the largest following. Each of these great leaders has his hosts of admirers, and to each science is greatly indebted. But what shall it profit mankind if revelation be set at naught, if the gradual evolution of man be clearly established, if evolution be shown to be untenable, or if the new theory of heredity be positively substantiated?

The electrician has accomplished wonders with his subtle *something*, already reaching out beyond the wildest imaginings of a few years since; and greater possibilities are in store. The chemist is exciting our admiration by his amazing synthetical skill—and yet greater things are ahead, whatever may be said of Prof. Berthelot's fancies. But what shall be said of the biologist? Surely, he is not indifferent to the times in which he lives. Upon him there rests an imperative demand. He, too, must do something for his fellow man; and, bold as the statement may appear, his is the grandest opportunity. He it is who is destined to alleviate suffering, to check the progress of disease, to lengthen the average of human life. Already has the noble work begun. To most observers the progress must seem slow, inexcusably slow. But with the exception of the time lost to human progress by the intolerant bigotry of the mediaeval church, it has been amazingly rapid. A glance over the field of scientific research of the past three hundred and fifty years can not fail to impress the observer with the wonderful acquisitions to biological knowledge. The great theories which have so closely held the attention of the civilized world for the past thirty-five years were dependent for their conception upon the wonderfully accurate morphological observations extending over that period of time. Early in the 16th century a school of anatomy was established in Padua; in 1619 Harvey discovered the circulation of the blood; soon after, the systematic classification of animals and plants became a distinct branch, and then followed the study of the smaller organisms. "We owe to this period," says St. Hilaire, "the foundation of microscopy; anatomy enriched and joined to physiology; comparative anatomy studied with care; classification placed on a rational basis." Céssalpin, Vesalius, Ray, Linnaeus and Van Leeuwenhoek of these early days were the pioneers, the necessary forerunners of Lamarck, Cuvier, Darwin, Hæckel and Agassiz. Koch and Pasteur are not distinguished as morphologists; but even the school of Bacteriology must be regarded as only another step in this evolution, and it is to this department of biological science that we look for great discoveries which are to emancipate man from terrible pestilence and infectious disease. As far back as 1683 an Amsterdam teacher, Anthony Van Leeuwenhoek, who had constructed a simple lens, began to study the bacteria of the mouth, and with wonderfully good results; his discoveries were, in fact, more marked than those reported by others possessing the compound microscope, owing, in part, to the difficulties encountered by them through spherical aberration. Little good resulted, however, and it was not until 1776 that the first systematic work was done upon these organisms. Another period of rest followed, and the middle of the present century was reached before there was any very marked advance. Then it was that a French chemist, presumably from philanthropic motives, threw himself into the struggle against this minute yet mighty foe. Pasteur was a true scientist, but he did not belong to that school of scientists represented by the man who thanked God that he had made one discovery that could not be turned to any practical use. Indeed, from now on his every effort seems to be bent toward the accomplishment of the greatest good; but his investigations have always been thoroughly scientific. The winemakers of France were soon deeply indebted to him for his important discovery regarding the souring of wine. But this service was outstripped in importance by his wonderful work in the cause of the silk industry of France. For several years there had appeared, annually, on many of the silkworm moths dark spots which were likely to produce disastrous results, when, in 1865, Pasteur was requested by the French government to investigate the matter. He found little foreign bodies always present in the blood of the diseased larva, and satisfied that these were the cause of all the trouble, he recommended that "good eggs" only be selected, some of which were to be hatched early; then, if "pea-green" was present, the whole lot was to be burned. They should save only the absolutely uninfected individuals. The effect of all this was the same old story—the world simply laughed at him. But, determined to stamp out this dread disease from the silk farms of his country, he himself purchased an abandoned farm. Here he applied his principles, with the result that it became the best silk farm in France. He had won, and his worst revilers became his sincerest admirers. This was the second notable victory for the great bacteriologist, though the organism he contended against in this case was not a bacterium, but probably a microscopic protozoan. Now the germ theory of both plant and animal diseases received a tremendous impetus. About this time a French apothecary discovered that carbolic acid would prevent seed from sprouting in the soil; that the miasma of swamps was associated with organisms whose growth was prevented by this acid; and that the inflamation of wounds was traceable to the same cause, and was allayed by the same application. Independently Sir Joseph Lister found that all inflammatory changes should be attributed to the same cause. Then followed antiseptic surgery, by means of which multitudes of lives are being saved and suffering so greatly alleviated. To those familiar with the "gangrene" so destructive throughout our late war, this important discovery must be hailed as one of the greatest achievements of the century. Anthrax, or splenic fever, is one of the most wide-spread of all infections in continental Europe among cattle. The American stock-raiser, though his tribulations are many, has never been called upon to face this dread evil, which has been known since the days of Moses, and of which Pliny writes as having spread three hundred years before his own time into Italy. Here, again, we see Pasteur's skilled hand; but now the work of that great German investigator, Koch, must be acknowledged, for here his brilliant career of general bacteriological research is said to have begun. He was soon able to detect the spores within the cells, and thereby to classify the anthrax bacillus. The honor, then, should be divided. After several years of patient study, Pasteur announced himself ready for a public test, and this was granted him. All of the animals inoculated with his weakened virus were shown to be exempt from the disease. As a result, millions of animals were soon inoculated, few of which succumbed to anthrax. This immunity lasts for but about one year, which renders it necessary to re-inoculate frequently ; again, the vaccination may itself prove fatal or not grant an "unconditional and reliable protection." Yet the fact remains that thousands of animals have been saved thereby, and statistics show that this protective inoculation is desirable in sections where the disease appears regularly. This, then, is another great victory over a once hidden foe. But Pasteur was to render still more important service. What form of infection is looked upon with greater horror than rabies or hydrophobia ? Instant death is infinitely preferable. Comparatively few, it is true, have been subjected to its tortures ; but all communities are liable to exposure, for none are free from dogs. Once bitten by an animal possessed of rabies this dread malady would continually haunt the victim and his friends — and, in many instances, death from hydrophobia ensues. We were told of "madstones" as sure preventives ; but however efficacious they may be few communities possess them.

How important it was, then, that some means of immunity should be discovered within the reach of all. With this end in view, the great humanitarian began a a series of elaborate experiments, the outcome of which is known over the civilized world. His method of treatment is that of progressive inoculation. He inoculates rabbits from rabid dogs, and after they have acquired the maximum intensity of the disease, the spinal cord is removed. Sections of this are kept for different periods of time in dry and sterilized air, the degree of virulency weakening with age. Taking an old, weakened section, a broth is made therefrom, and with this the patient is inoculated. A little later, broth from a more recent section of cord is used, and so on, the virus becoming less and less attenuated until the body acquires a tolerance for the bacteria. In this way perfect immunity is secured, the records showing only about one failure out of every hundred persons treated. The cases cited strongly attest the importance of biological work, and throw a faint ray of light upon future possibilities. Few diseases are yet conquered, but the history of *their* conquest leads us to hope, nay, to confidently expect, many more to follow in their train. Smallpox, anthrax, hydrophobia—three once dreaded animal diseases, all brought under the power of man. And now the announcement is made that diphtheria and typhoid fever have also been made captives. It matters not to us whether France or Germany establish its claim for priority ; we are interested only in the final result. But some may be led to undervalue the work of the biologist, because of the unsatisfactory results attending the attempts to secure immunity from tuberculosis. The failure is freely admitted ; but it must be borne in mind that the reputed discoverer of tuberculin, Koch, never made the claims that his friends made for him. He has never assumed that he had fully mastered the disease. Furthermore, it is claimed that "Koch's specific" had been discovered prior to this, in Pasteur's laboratory by a Russian exile. But while not a preventive, it is extensively used in diagnozing the disease among cattle. Acknowledging, then, the futility of the attempts made to secure immunity from this and some other maladies, of what benefit are the continued studies upon such infectious diseases ? Of incalculable benefit. The better a disease is known, the greater the safeguards that can be recommended. Our knowledge of the tubercle of consumption gives a far better knowledge of how to avoid and ward off that fatal disease. Since the fact has become recognized that it is infectious, many precautions have been taken that were before unknown. Such is likewise true of other diseases due to the presence of bacteria.

It is but fair to state that while smallpox is fully under the control of man, its ætiology has not yet been determined. Jenner succeeded toward the close of the 18th century in staying the ravages of this terrible scourge by vaccination with "cowpox virus, and Pasteur, who has investigated the nature of this virus, has concluded that it is an attenuated form of that of the smallpox.

Disinfectants have been employed from very early times, and it is probable that not a little of the Levitical law of cleansing was based upon some real knowledge of the value of disinfection ; this seems to have been true, also, of many heathen ceremonial practices. But for the more perfect means of preventing the spread of contagious or infectious disease, and securing absolute deodorization, we are again indebted to modern biological knowledge, and that acquired within the last few years renders it possible to secure in our hospitals practical immunity from contagious disease for patients under the same roof with infected inmates ; to easily check the progress of dread infections in large cities ; to prevent the spread of pestilence from city to city, and to effectually shut out from our shores the plagues that depopulate large areas in Europe and Asia. There is, perhaps, no department of our government deserving higher commendation for effectiveness and thoroughness than the Marine Hospital service. Through it, strict watch is continually maintained that "no plague shall come nigh our dwellin," or, if it does approach, it shall meet with a "thus far shalt thou come and no farther." During the plague of Asiatic cholera in the summer and autumn of '93, such tireless, faithful watch was kept at our ports, particularly New York, that not one exposed passenger was allowed to land and walk the streets until he and his effects had been thoroughly disinfected. For this, much credit is due to the health department of that great city, indicating that with all the corruption and rotteness of that government, here was one department that did not itself need fumigating. Now, in all our large cities boards of health are established, and, where public health is not shamelessly sacrificed to political ends, men of scientific mould are secured to administer their affairs.

Careful and painstaking experiments have led to the discovery of various preventives by which infectious disease may be warded off. First, we may properly mention heat, a means within reach of all and best adapted for the destruction of pathogenic organisms under certain circumstances. It may be said that a dry temperature of 150° C. (302° F.) applied for one-half to three-quarters of an hour and freely escaping steam (100° C., 212° F.), for the same time, will, in the great majority of cases, prove effective, even for the killing of spores, which are so very resisting. But this is often impracticable, and other methods must be resorted to. It may be mentioned in passing that cold and sunshine are sometimes efficacious, the former in the case of cholera ; but chemicals are the most freely resorted to of all. Chlorine, while often successfully used, is not sure. Carbolic acid is much over-estimated, and its vapor is useless. The vapor of sulphur is good, but to be effective a large quantity of sulphur must be burned. To disinfect a room, all the doors and windows must be closed, and for one of ordinary size not less than fifteen pounds should be used, together with a little water. Salts are shown to be the best disinfectants. Mercuric iodide, silver iodide, mercuric chloride, and silver nitrate is the order in which the principal ones have been ranked, with reference to disinfecting quality. The most common of these is mercuric chloride (corrosive sublimate). It is quite poisonous, however, and must be used with care. It is commonly used in the proportion of one to 1000 parts of water. In dentistry and surgery, hydrogen peroxide is now extensively employed, and it is one of the best antiseptics that can be applied in diphtheria for washing out the throat. Calcuim hypochlorite is a disinfectant of great value for sick-rooms. Others, including zinc chloride, may sometimes be employed to advantage. To disinfect clothing, the biologist recommends boiling in water, steaming, or soaking in corrosive sublimate (one to 2000), and in some cases burning. For mattresses we are told to treat with super-heated steam, to boil in water at least one-half hour, or, again, to burn ; while for the hands (and they should be much more frequently treated than is now the case) corrosive sublimate, one to 1000, or hypochlorite, 12 to 100, are both used. Certainly, amid all these safe-guards, infectious and contagious diseases can be much easier controlled than formerly. And we see this illustrated continually in every community that is properly enlightened.

Not the least of the practical triumphs of biology is the invaluable work done upon drinking water. While much can be determined from chemical analysis, this is not sufficient. It is possible for the chemist to detect conditions indicating the presence of organisms in water (when there in sufficiently large numbers), but it remains for the biologist to identify and determine the nature of those organisms. As a result of these investigations, whole communities are protected against the use of contaminated water, and individual owners may ascertain the quality of the water in wells and springs. It is especially imperative that we watch well our water supply, for statistics show conclusively that we are drinking more water than ever before. This will be received with surprise by many, but it is nevertheless a fact. It was formerly considered that 40 gallons a day per individual was all that need be planned for in the construction of water works; now, 100 gallons are reckoned upon as the proper supply. It follows, of course, that great quantities run to waste, and that much is consumed that is not actually needed. It is not claimed that more than two diseases can with certainty be traced to the water supply of our great cities, viz., typhoid fever and cholera. The mere presence of bacteria in water does not, of itself, indicate an unhealthful condition. These organisms are found almost everywhere, and it is only the pathogenic forms that here especially interest us, though it may be well to note some of the discoveries of bacteriologists relating to the general distribution in water of non-pathogenic bacteria. The naked eye cannot determine the healthfulness or unhealthfulness of water, for that which is clear and sparkling may contain the deadliest micro organisms, while that from which we would instinctively shrink because of its turbidity may be used with perfect safety. Bacteria will be found in both, but the harmful forms often thrive in an environment where none but the expert would expect to find them. This fact should be impressed upon everyone, that dangerous jumping at conclusions may be avoided.

There seems to be an impression abroad that clear looking ice must necessarily be pure; but here, again, the public is in error, and so dense is the ignorance upon this point that danger signals should be thrown out and the people warned against the careless practices in vogue. That ice is a medium through which disease and death may be conveyed is evidenced by the fact that bacteria are found to thrive in vast numbers in the ordinary ice employed for domestic purposes. An elaborate series of investigations were conducted in Berlin, by Dr. C. Frænkel, upon the lake-ice supplied by one of the companies of that city, which showed exceedingly variable numbers of bacteria present, ranging from 21 to 8,800 per cubic centimetre. In some instances, Berlin ice was found to contain fully 25,000 per c. c., while, on the other hand, ice manufactured from distilled water was almost entirely free from organisms. Surely, one would suppose that ice formed from carefully sterilized water would prove an inhospitable abode for these microbes. But the further observations of the bacteriologist do not warrant any such supposition. Investigations with true *pathogenic* bacteria show some surprising results. Portions of sterilized water were selected, into which several species were inoculated. This was then frozen, and at the end of 11 days typhoid bacilli were present to the enormous number of 1,000,000 to the cubic centimetre; in 77 days they had decreased to 72,000; and after 103 days there were still 7,000 of these deadly micro-organisms present! This must be convincing to the most skeptical. Ice *is* a dangerous medium for the spread of infectious disease. But, should the temperature be varied, it seems clear, from close observations, that the danger will be greatly lessened; for typhoid bacilli frozen for 24 hours and interrupted by three thawings were reduced from 40,000 to 90, and they had entirely disappeared at the end of three days. Much the same results have been observed in the case of cholera bacilli. But while the matured forms of these organisms will succumb to repeated freezings, it is quite another matter to overcome the resisting qualities of the spores. A mixture of the spores and bacilli of anthrax introduced into steam-sterilized water which was frozen upwards of 30 times, showed that those spores which survived the first freezing were not destroyed by succeeding frosts. The *bacilli* of this species succumb to these changes of extreme temperature as surely as those of the pathogenic types just mentioned. The lesson taught by these observations is this: Look carefully to your ice-supply; insist upon knowing the character of the water from which it is taken; avoid ice-water that you know nothing about.

Though of no especial practical importance, painstaking investigations have been made upon snow and hail to determine the presence or absence of microbes. Janowski found considerable quantities in freshly fallen snow, and Schmelk reports them present in the snow of a Norway glacier at a height of 5,900 to 6,500 feet above the sea-level. Far greater numbers are found in hailstones. Though there have been few determinations of the number of these organisms present in rain, it has been estimated that with a rainfall of 66 cubic centimetres about 5,000,000 micro-organisms fall annually upon every square metre (10¾ square feet) in one part of France.

It has been shown that running water contains far more micro-organisms than are found in lakes and reservoirs. Storage purifies the water, the bacteria brought in by the streams sinking to the bottom. Furthermore, the banks of rivers cannot be as easily protected. Those cities, then, that are supplied from lakes are more secure than those taking their supply of drinking water from streams. It is surprising that, with all the information furnished them by the biologists, such cities as Philadelphia will continue to depend upon the tainted, disease-laden water supplied by streams of which the Schuylkill is a type. Chicago has not been much better off, though efforts have been made to insure a more healthful condition by sinking a "crib" farther out in Lake Michigan. It is not generally known, however (and probably now appears for the first time in print), that on frequent occasions the crib near the shore has been opened and water pumped from that into the city for drinking purposes. This is believed to have been the cause of the last epidemic. Spring-water protected from chance contamination is most desirable, it having been known in some cases to yield no micro-organisms to observation, thus closely resembling the deep artesian well. But such sources of supply are for the few and not for our densely populated cities.

In seeking a pure supply of water, the best means of filtration is made a constant study. Sand filtration is a very old method, having been introduced into London as early as 1839; but it was looked upon with ill-favor as long as the chemical analysis was mainly relied upon. But in 1885 Koch's gelatine-process of water examination was applied there, with astonishing results. In the following year it was shown that by sand filtration alone there was a reduction in the water of the Thames, for the twelve months, of 97.6 per cent. in the number of bacteria colonies per cubic centimetre; in 1887 of 96.7 per cent., and in 1888 of 98.4 per cent. These examinations are convincing, not only of the efficacy of the sand filter, but also of the unreliability of the *chemical* analysis as a sole guide in determining the character of water. This method of filtration is in use for the water-supply of Berlin; and here, again, a very high percentage of bacteria was eliminated. The practicability of the sand filter for lake-water, which contains so few micro-organisms, is evident from tests made on the water supply of Zürich, where filters can be kept working from three to four years and continue to yield a very pure filtrate. The records of the workings of sand filters in some cities in Germany do not show the same satisfactory results as those reported from London and Berlin; but it is evident that the particular process in use in the former cities is an inferior one. Bacteriologists have proven that certain processes of sand filtering will separate from the water nearly all the micro-organisms present, and that it is, therefore, thoroughly effective, reducing very materially the number of pathogenic germs that may be present. Remarkable evidence of the value of sand-filtration is furnished by a study of the cholera epidemics in Hamburg and Altona in 1892 and 1893. These two cities are situated, side by side, on the Elbe river, upon which they are dependent for their water supply. Hamburg, being above Altona, is more favorably situated; it obtains its water some distance up the stream, but the latter city uses the contaminated river-water after it has received the sewage of some 800,000 Hamburgers. What was the surprise, therefore, when it was announced that the dread cholera had broken out in the more favored city, and that thousands of people had perished therefrom, while in Altona the disease was scarcely felt! This was the more astounding from the fact that the epidemic had approached to the boundary line between the two cities, where it had stopped; and of one street which marked the division for some distance, we are told that the Hamburg side was stricken down, while the opposite side escaped the disease. It was soon announced that only those houses supplied with Hamburg water were visited with the plague, not a case being reported where the water of the sister city was used. A surprising statement when one considers the foulness of the water furnished Altona. But one explanation, however, could be made. In the plague-stricken city unfiltrated water was used, while in the other an exhaustive process of sand-filtration was in practice. However, during the following winter the tables were turned, and Altona was suddenly visited with the cholera epidemic. The authorities were completely nonplussed; but a searching investigation revealed the fact that the number of bacteria in the water had increased from 50 to 1,000 and more to the cubic centimetre. This led to the conclusion that the filtration was defective, and further search showed that one of the filters which had been cleaned during the cold weather had become frozen over, rendering it unable to retain the bacteria. The progress of the disease was not nearly so marked as the summer before in Hamburg, and this Koch ascribed to the fact that the imperfectly filtered water was materially diluted by that passing through the yet perfect sand filters. Here is a striking illustration of the practical value in counting these micro-organisms, as this led directly to the discovery of the true cause of the epidemic which made possible the speedy stamping out of this disease.

The efficacy of sand for filtering is still further shown in the exhaustive investigations conducted by the Massachusetts State Board of Health upon sewage, the method adopted being that of intermittent filtration. Very coarse sand, five feet deep, allowed from 26 to 40 per cent. of the bacteria to pass through; fine sand, same depth, 14 per cent; very fine sand, same depth, 5 per cent.; a mixture of coarse and fine sand and fine gravel, 3¾ feet depth, 5 per cent.; the same with 10 inches sandy loam and 6 inches brown soil, 5 per cent. In the case of garden soil and of peat, each 5 feet in depth, so few bacteria were found in the effluent that they were not supposed to have passed through the filter. But it must not be concluded that the surest filters are the best for practical purposes, for in the last cases the rate of filtration is exceedingly slow. Enough has been said to conclusively show the practicability and high value of sand for filtering purposes on a large scale. But for domestic purposes such materials as animal charcoal, vegetable charcoal, iron sponge, brick-dust, coke, powdered glass, very fine ferruginous green sand and silver sand have been more or less extensively used; and elaborate experiments have been conducted in England, the results being presented before the Royal Society. It was determined that at first all these filters except those constructed of silver sand, glass, and brick-dust, completely shut out all organisms; that after twelve or thirteen days' action an absolutely perfect filtration was effected by iron sponge and animal charcoal; and that after one month's continued use iron sponge showed a reduction of 99.8 per cent., vegetable charcoal of 95 per cent., and ferruginous green sand 39 per cent., while animal charcoal indicated an increase. Coke gave the surprising result of 98.5 per cent. reduction of these organisms after five weeks action. Vegetable carbon, therefore, in the form of charcoal or coke, must now be ranked among the first as biological filters, and as this material is cheap and plentiful it can well be put to general use; but considered chemically it is practically inactive. The Pasteur-Chamberlain filter, so extensively used, is made of biscuit porcelain, and, where a large amount of water is to be passed through, several cylinders are employed. Though not influencing the water much, chemically, it has proven itself efficacious in the removal of bacteria, when new; but it loses this power after a short time, rendering it necessary to remove, clean and sterilize by heat, say every four days. Though stone filters have been long in use, bacteriological examination shows them to be absolutely unreliable. The same may be said of those constructed of asbestos.

Another means of securing better sanitary conditions, for which we are indebted to the biologists, is the treatment of sewage by chemicals. When a nuisance exists, we may usually ascribe it to the "development of organisms fed by the organic matter and nitrogen compounds of the sewage." It follows that, as we remove this food, we shall be able to materially reduce the number of the objectionable bacteria, though the proportion of *organic matter* removed does not necessarily represent the exact proportion of food for organisms removed, as some organic matter is in no sense of the word a food for bacteria. The specialists have already succeeded in removing from one-half to two-thirds of the soluable organic matter in sewage, by precipitation with iron or aluminum salts, and the number of bacteria present has been greatly reduced. We are, then, led to hope that much good will result from these discoveries.

The employment of filters is to be encouraged, but, when not at hand, infected water may be rendered absolutely safe by boiling; indeed, in some cases it would be the wiser course to filter and then sterilize in this way. The observations of Currier led him to assert that a temperature of 100° C. (212° F.) maintained for ten minutes would destroy the spores of tubercle bacilli, while anthrax spores would succumb to five minutes boiling. He further stated that typhoid and diphtheria bacilli were destroyed by bringing the water to the boiling point and then allowing it to cool; also that the cholera bacillus could not resist an exposure to 70° C. But while noting these observations which were made in 1890, we would strongly advise the comsumer against the danger of attempting to put them into practice. It is infinitely preferable that over-time should be advocated for general purposes than a strict adherence to the minimum time claimed by this observer. While this method of sterilization is depended upon, a maintenance of the boiling point fully one-half hour would be a far better rule to follow.

We have dwelt to considerable length upon the application of biological knowledge to drinking water because of its far-reaching, vital importance. Facts here given furnish a sufficient guide for the methods of procedure in the avoidance of infected water.

One of the great sources of infection is milk. Recognizing this fact, and that young children are wholly dependent upon this food, bacteriologists have been able to give to the world a practical method of sterilization, by means of which the milk will be rendered absolutely germ-free, thus saving the lives of thousands of infants yearly. A practical method however, of securing this result was not hit upon in an instant. When it was first suggested in Germany that all milk be sterilized, physicians readily responded, for it was recognized that the diseases of children would thereby yield more readily to treatment. But it does not follow that milk thus sterilized should constitute the only food, for experience in a Philadelphia hospital has shown that where this was practical, a large per centage of the children died; that the weakly children could not thrive upon it. Milk, as it leaves the cow, is already nearly "digested," and intense heat melts the fats and destroys emulsion; it turns the milk sugar into a caramel; it destroys the starch ferment (infant's saliva containing no ptyalin); the casine will not curdle, and the albumen is coagulable. Milk thus treated, then, is unfit for a steady diet. But the bacteriologist is again equal to the emergency, and has succeeded in showing that Pasteurizing renders the milk just as effective. This is based upon the discovery that it is not necessary to bring the milk to the boiling point to destroy the pathogenic organisms, a temperature 70° C. (158° F.) being sufficient. Thus it is possible to thoroughly sterilize all the food of young children, and at the same time retain the essential properties of that food. The milk should, however, be used soon after sterilization. Not only are the bacteriologists thus able to guard the children against disease communicated by milk, but the general milk supply has been very carefully studied and precautions advocated, which, if followed will insure markedly decreased death list. There appears, too, good reason for declaring that milk acts as a carrier for at least five diseases, viz.; tuberculosis, typhoid fever, scarlet fever, diphtheria and cholera infantum. But it has been shown by these biological specialists that milk may contain myriads of bacteria, and many varieties, and yet still be used with perfect safety. For example, remarkably "pure" milk tested in Boston was found to contain 2,000,000 bacteria per cubic centimeter (about .06 inch), while in Germany as many as 200,000,000 bacteria have been found in the same small quantity, and yet we are told that of all this vast host probably not one was injurious. Furthermore, from 40 to 50 species have been described that have the power of souring milk. Indeed, the presence of bacteria is essential to produce souring. Thus it is seen that the specialist may have to labor against difficulties in determining the presence of possibly a few bacteria that have the power of producing infectious disease, and his difficulty could be the better appreciated were it realized how nearly alike all these organisms appear. It is only by the employment of most skillful means that it is possible to state positively that an organzm thus found is a pathogenic bacterium, and to accurately classify it.

But the biologist (through bacteriology) is benefitting the world not only in amelioration of human suffering and in the eventual lengthening of the span of life, but he has come to man's aid as a bene.actor in a most unlooked for direction. While the organic chemist is seeking to supplant natural by artificial foods, the biologist seeks to render those foods (in the production of which millions of our fellow men secure a livelihood) more palatable thus placing the natural producer at a far greater advantage, and furnishing him the means for successful competition with the artificial food producer. This is at least true of one important staple from which so many of our farmers derive, or have derived, a considerable revenue. Within two or three years, it has been announced from time to time that experiments were in progress looking to the adoption of a method that would insure a high grade of that great dairy product, butter ; and now biology is prepared to proclaim to the world the successful outcome of these investigations. This has been accomplished by a most remarkable means : Heretofore, the bacteriologist has been devoting his time and energy mainly to those members of this class of organisms whose very presence brings untold suffering. The great desideratum has been and is, how to get rid of them. But now we learn of a group of bacteria through the cultivation of which a most desirable end has been attained. Bacteria, and they alone, possess the power of rendering delicious the product of the ordinary dairy, and insuring for it a high market value. That aroma and flavor which characterize the "gilt-edge" brand of butter can be easily secured in the ordinary farm dairy by making use of these organisms. This being an assured success, then, what may we not look for along the same line ? By making the *best* use of those bacteria that are beneficial to man, great achievements are in store for us. The farmer is directly dependent upon these organisms for the nitrification of his clover crop, and this is a most important factor upon the farm. Nitrogen is all important for the sustenance of life. A German chemist has said that the explosion of powder in a gun does more harm than the bullet that it propels. Nitrates are scarce and exceedingly costly, and man is dependent upon bacteria for their formation. Plants, not being able to feed upon animal nitrogen as albumen, it is necessary that the latter should be broken up that the nitrogen may be utilized. This office is performed by bacteria, two distinct kinds having been described, the one a decomposing, the other a synthetic bacterium. But vast quantities of free nitrogen escape annually into the air, and certain of the legumes are able to regain a portion of this gas, thanks to the bacteria present in "root-tubercles."

Thus through clover, pea, bean and other crops of this order, the farmer is able to reclaim this invaluable element from the air and restore it to the soil in a form suitable for reception and assimilation for other plants. Now, with this information already in hand, does it seem improbable that the biologist can here greatly aid the agriculturist?

It must be admitted that for a knowledge of these facts we are indebted to the chemist, who, by his careful analytical work, showed us the value of nitrogen as a plant food and also called attention to the nodules upon the roots of the legumes. The bacteriologist has here simply followed in the chemist's wake, and, with forces joined, the work of these specialists can but result in great good to agriculture, and hence to all. It is surely pleasanter to contemplate a building up of this all important industry than a pulling down, as suggested by the great French chemist. The biologist holds out no promise of a Utopia for any class of men; he bases his claims for the future upon what has been actually accomplished. It is possible that some enthusiasts, eager for sensation, may draw upon their imagination and create false impressions, as was done in the case of Koch's tuberculosis discoveries ; but the biologist is no sensationalist, nor indeed, is any true scientist. Take him at his word, allowing him to place his own construction upon his discoveries, and surely no harm can come from *his* investigations, but much good will result.

With epidemics a thing of the past, with general disease so materialy lessened, with surgery so uniformally successful and a consequent higher average for the duration of human life, what of the future temporal condition of man ?

As the world becomes more densely populated, its resources are diminishing, slowly it is true, but yet diminishing.

Here we are brought face to face with Malthusianism. Granting that Berthelot's dream may be realized, then the arguments attending the discussion of this old doctrine must be materially modified ; but, from the standpoint of the biologist alone, it must be admitted there seems ground for fear. Without here attempting to discuss this important social problem, certain facts must be noted. We are here because others have passed on and made room for us ; others will come upon the scene because we shall pass on and make room for them. Nearly three thousand years ago one recorded the limit of man's life, and amid all the varying environments, this has been wonderfully constant. Furthermore, it does not seem at all probable that this limit will be greatly modified. All these conquests of biology in staying pestilence, in establishing perfect sanitary conditions, etc., will undoubtedly prolong the *average* of human life ; but it does not necessarily follow that the days of our years shall be much prolonged beyond the "three score and ten," or at mos the "four score." As in the past, gentions will pass away to make room for succeeding generations. So the problem that our successors will be called upon to face will not be so serious a one as might at first appear. The socialistic dream of one vast republic covering the entire habitable face of the globe must refer to a condition far, far into the future. A geometrical ratio of increase supported by only an arithmetical ratio of sustenance would, it is true, hasten the time when the utmost limit would be reached ; but with the recent achievements of biology and chemistry new factors enter into consideration. As the former throws safeguards about mankind, whereby the ratio of increase is materially raised, the latter is determining means of cheaper subsistence. We need not attempt to cross the imaginary bridge that Berthelot has built, but rather deal with facts based upon what these sciences are actually doing.

Science is progressive. There are no outside influences to hold it in check. Once, an attempt to benefit mankind by adding to the world's limited store of knowledge was met, not by encouragement, but by severe persecution. Now, all is changed, and, while the spirit of intolerance has not entirely disappeared, a marked exhibition of that spirit would prove a veritable boomerang ; the world will no longer calmly submit to interference with the work of the honest scientist, be he biologist, geologist, chemist, astronomer or physicist. Leaders of bodies whence opposition once came readily recognize this fact, and that the truths of science cannot in any way disturb the mighty truths they represent. The wonderful strides that mark the nineteenth century are but the natural result of non-interference. An untrammeled science is rewarding the world for its sympathy — a sympathy never so strongly pronounced as in these closing days of the century.

However, it must be acknowledged that this is not the special age of biology. It must stand aside for electricity, for any achievement in which the world has almost ceased to wonder. But as geologists recognize the beginning of an age back, far back in one preceding where the new forces at work were preparing for the grand culmination centuries later, so here, in this age of electricity, biology is gathering its forces together for wonderful results sure to follow.

BOOK NOTICES.

Second Book in Physiology and Hygiene, by J. H. Kellogg, M. D., New York : American Book Company.

This book is quite elementary in character, but it is pleasant to note that the pupil has placed before him a scientific treatment of the subject. Many books of this character leave the young student completely in the dark on subjects here made clear. The book is delightfully written and well illustrated. For grammar school grades it must be a valuable acquisition.

A Practical Flora. By O. K. Willis, A. M. Ph. D., New York : American Book Company.

The object of this book is to familiarize the pupil with plants used for food and having a commercial value, not alone those belonging to our American flora, but including also plants of the tropics. Here is a decided departure in botanical text-books. So marked is this innovation that one is at first a little startled. But in studying the plan of the book the author's idea can but command respect, and, as he includes many of our common wild flowers, the pupil can very profitably devote a term to this method. The illustrations add greatly to the value of the book.

School of English, by George P. Butler.

This book proposes the following objects : (1) The reading and discussions of selections from standard English authors, (2) constant practice in composition, (3) symtematic correction of the pupil's work, (4) the study of rhetoric for the purpose of cultivating the pupil's power of criticising and improving his own writing.

We have also received from the same publishers Milton's L'Allegro Il Penseroso, Comus, and Lycidas ; Eliot's Silas Marner, Macaulay's Essay on Milton, and Shakspeare's Midsummer Night's Dream. These books are the latest addition to the Eclectic English Classics.

Editorial Notes.

Owing to the fact that the Legislature has decided to meet hereafter biennially, the usual Report to the General Assembly will not be issued this year. Neither will the University catalogue, which usually appeared simultaneously with the Report, be published. The last general catalogue was printed in '85; in the usual order of events the next will be issued in the spring of '95, together with the regular annual catalogue. In the meantime that for '93-4 will be sent out, together with this circular, as long as the supply lasts. These two documents will answer all questions, as few changes and none of importance have been made in the University during the past year. The attendance and distribution of students for the fiscal year ending with the fifteenth of November, is as follows:

Post-graduate	10
Graduates	11
Seniors	13
Juniors	18
Sophomores	20
Freshmen	49
	121

The whole number in the Preparatory Department was 197; to which are to be added 7 unclassified students. In this number are included

Piano students	23
Voice students	9
Students in Book-keeping	13
Students in Stenography	11

One year ago, November 15, the attendance was distributed as follows:

In collegiate and post-graduate departments	112
In the preparatory department	205
	317

There has, therefore, been an increase of eight students over last year, and wholly in the collegiate department.

As the attendance now represents eight different States, the University may fairly claim to have more than a merely local reputation. It is the wish and hope of the Faculty to so increase the attendance in the collegiate department that students of this rank will soon require all their time and attention. On the whole, the limit of our present facilities has very nearly been reached, and we much prefer to instruct a small body of earnest young men and women rather than a much larger number who attend school chiefly because they are sent. A good part of the preparatory work, especially that in the so-called common branches, can be done during the summer term, and we strongly urge young people to avail themselves of the opportunity.

A great deal of attention is given to the Library. Consignments of new and antiquarian books are received every month. During the present year the increase of the Library has averaged about five volumes a day, and there are few books needed for class use or special study, that we have not been able to acquire when wanted. We believe there are few colleges better equipped in the quality and number of books on hand and the facilities afforded for their use. Students have access to the Library every day for the purpose of consulting works bearing upon the subjects they are studying. They are, moreover, encouraged to draw books for private perusal whenever they have the time to spare for this purpose. The members of the Faculty are always ready to advise students in this respect and do all in their power to encourage them to investigate subjects in which they are interested and to impress upon them the importance of systematic research. It is due to our students to say that a majority of them improve the opportunities placed within their reach. The Library is seldom open that it is not frequented by students in quest of books or articles to which their attention has been directed. The reading room is regularly supplied with current magazines and with reference books. As soon as the volumes are complete the periodicals are bound and become a permanent part of the stock of books on hand. The growth of the various libraries connected with the University has been so rapid within the last few years that it now numbers fully twenty thousand volumes.

THE religious interests of the University have never received so much attention as at present. Dr. Powell, pastor of the Presbyterian Church, has been delivering a series of Friday afternoon lectures on Prophesy. The Faculty has also arranged for a course of Sunday lectures for the winter and spring terms by prominent clergymen within easy reach of Athens. A room has been provided for the Y. W. C. A., and has been neatly and tastefully furnished by the members. The same place is also used for the meetings of the Adelphia Society, that were formerly held in the Chapel. The Y. M. C. A. have likewise a place of meeting and have begun the formation of a library consisting chiefly of missionary literature. The regular Thursday evening prayer meeting is kept up and is attended by a considerable portion of the students. It is the earnest desire of the officers of the institution that the religious and moral interest of the students shall be fostered in every possible way. There is probably no college or university in the country where these important matters receive a greater share of attention. We hope to make clear to those who have been with us any length of time the importance of a well-grounded religious faith and a high standard of morality as an equipment for the duties of life.

IT is extremely unfortunate that so narrow a view prevails as to what should constitute a commercial education. In our day when competition is so strong among men engaged in the same business, as well as between different commodities offered for sale, it ought to require no argument to prove that prospective merchants need to be equipped with all the intellectual outfit possible, to enable them to make headway against their rivals. But instead of this, what do we see? Young people with not even a good common school education taking a so-called commercial course that requires a few weeks or at most a few months, in the delusive expectation that they are in this way prepared for business. Leaving out of the question entirely the matter of culture, and viewing the situation solely from the standpoint of such knowledge as can be turned to account, what ought the business man whose aim is something more than to be the manager of a corner grocery to know? Above all things he ought to have that largeness of mental horizen that will enable him to consider every phase of business from every side. This can not be acquired on the basis of the education provided by the average public school. Then as a citizen more than any other class the merchant ought to know the history of our country politically and commercially. He should be familiar with the principles of political economy and especially with the financial phases of it. That he needs more than a mere smathering of commercial law ought to require no argument, and what shall we say of his relation to municipal government and municipal affairs in general? How dearly tax-payers continually and almost everywhere have to pay for the ignorance of municipal officers, to say nothing of their venality and lack of public spirit, is too notorious to need any emphasis from us. The prosperity of the country is more largely in the hands of its business men than of any other. We can not here discuss this question at any length. Our object is merely to call attention to the erroneous views that prevail and to the cost of ignorance. The time has passed when our young men can be expected to learn everything, or almost everything, by their own experience. Some things can be got only in this way, but he is a fool who is satisfied to become wise by his own experience when he might turn that of others to profitable account. And how quickly he acquires knowledge who starts out in life for himself with a well trained mind and a large fund of general information. The average commercial course is a very unimportant matter and ought to be regarded as the completion of an education rather than the whole of it. The Ohio University is doing what it can to dissipate the prevailing error. It does not promise to make competent merchants in a few months. Its aim is broader and higher, and wiser.

On the evening of November 17, Miss Stinson, assisted by several of her pupils, gave a recital with the following

PROGRAMME.

Sonate. { a. Allegro, b. Andante .... *Bohm*
Misses Jessie Falloon and Florence Craig.

Rondo, op. 51, No. 2.................. *Beethoven*
Miss Annie Jones.

All Through the Night.................. *Boulton*
Mr. Newman Bennett.

Duett, op. 250............................ *Bohm*
Misses Grace Gist and Bertha Hoover.

Invitation to the Galop.................... *Bendel*
Miss Florence Craig.

A Night in Venice........................ *Arditi*
Miss Jessie Falloon and Mr. Newman Bennett.

PART II.

Allegro, from Symphony in G. Major...... *Haydn*
Misses Inez Riddile, Elizabeth Brown, Myrtle Stinson and Ralph Super.

Valse, op. 60.......................... *Newland*
Miss Grace Gist.

Still is the Night .... *Abt*
Miss Jessie Falloon.

Sonate. { a. Allegro, b. Adagio, c. Presto..................... *Haydn*
Miss Inez Riddile.

Waltz, op. 34, No. 1 .... *Chopin*
Miss Elizabeth Brown.

Entreat Me Not .... *Oakes*
Misses Jessie Falloon and Madge Buck, Messrs. P. A. Bright and N. Bennett.

Young people who wish to become stenographers make a serious mistake in supposing that they can be successful without a considerable degree of literary culture. A large vocabulary at ready command is essential. One can not translate into longhand the abbreviation of a word with which one is not familiar. The average newspaper reporter is wholly unreliable when he reports a speech upon a subject with which he is not familiar; and this is pretty nearly all the time. To remedy this unfortunate state of affairs, more extensive general knowledge is essential and a readier familiarity with the English language. In our work in this department we lay great stress upon these points. We claim to do it a great deal better than the average commercial college, but we must have much more time. Generally speaking, it is not wise for a student to take stenography without also devoting a good deal of time to English grammar and rhetoric.

Owing to the increase of students in the musical department it has been found necessary to employ an additional teacher. Miss Lula C. King has been chosen to assist Miss Stinson, and began work at the opening of the Winter term, December 3. She will give her attention chiefly to voice training. Miss King was for four years a pupil in the Cincinnati College of Music and has for several years been a very successful teacher in that city. She has besides been a member of some of the best church choirs. Students will be accepted who wish to take music only. The terms are as follows:

Piano or Organ, term 13 weeks....	$13 00
Voice Training, " "	13 00
Both at the same time	23 00

For those who take other studies the charge will be $7.00 additional. It will be seen that these prices are much lower than they are elsewhere for instruction of an equally high grade. Those students who have attained a fair degree of proficiency as players will receive certificates whether they have taken other studies or not. Music is likewise an elective among the studies leading to a degree.

A SUMMER term will be carried on as usual during the months of July and August, '95. The date of opening has not been definitely determined, but it will probably be immediately after the close of the regular spring term. Instruction will be offered as heretofore in the common branches and also in several more advanced subjects. A special circular will be issued early in the coming year giving exact information on all matters likely to be of interest to intending students. It is hoped that the term can be so arranged that it will close just before the opening of the Athens County Institute. As the Institute is to continue three weeks, the proposed arrangement will afford all who wish an opportunity to add this time to the instruction of the summer. Students so desiring will be credited with such work leading to a degree as has been satisfactorily performed.

As WE have frequent requests from correspondents for information regarding the character of the work done in our electrical department, we repeat once more that its aim and purpose are entirely practical. It is specifically adapted to the work of students who have had some experience in operating plants, but no knowledge of the theory underlying the force with which they have to deal, and to persons who have little or no knowledge of either, but who wish to become practical electricians in the shortest possible time. Students in this department take turns in operating the college plant in the evening, while the daytime is spent in the study of books and the reading of periodicals that treat of the various phases of the subject. The object constantly kept before the learner is the practical application of electrical energy to the propulsion of machinery. The course requires about two years for its completion, when the learner knows only the "common branches." Those who are somewhat proficient in the elementary principles of mathematics may complete it in one year. The subjects to be studied are almost wholly in the preparatory department and do not of themselves lead to a degree. Few of those who pursue them are interested in a degree. Their aim is to acquire the practical knowledge for which an opportunity is offered. There is no extra charge. The students in this department pay only the regular tuition, but in common with those in the other departments, are charged with the materials consumed. There is a sufficient supply of tools for working wood and iron to supply all the needs of the department, and the manual training element is made prominent. Fuller details may be found in the regular catalogue. There is here an excellent opportunity for a small number of students to gain in the shortest possible time a thorough acquaintance with the elementary principles of electrical engineering and their practical application.

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Personal Notes.

L. E. Armstrong '94, has been teaching in Henning, Tennessee.

Several members of the present senior class intend to pursue post-graduate studies at the O. U., or elsewhere, or both.

Specimens of fossil forms were taken this fall from North Hill and the sewer excavation near the B. & O. S. W. track.

The Starling Medical College of Columbus now admits to its second year's course of lectures students completing the Preparatory Medical Course of this University.

E. J. Jones '73, of the well known legal firm of Grosvenor and Jones, spent part of the summer and fall on a business and pleasure trip in Great Britain and on the Continent.

During the Fall, Professor Gordy lectured at Teachers' Institutes in Columbia, York and Adams counties, Pa. His lectures were very highly spoken of by the local press.

Hon. J. L. McMasters '69 was the Republican candidate for Circuit Judge of Marion County, Ind., in the last campaign. Of course he was elected, and by more than three thousand majority.

The members of the Ohio Conference, M. E. Church who are alumni of the University are at present stationed as follows, so far as we have learned: T. M. Rickets, '80, Chatham; Dr. J. H. Gardner '59, Columbus; T. B, White '86, Middleport; A. J. Hawk, '79, Wellston; W. A. Hunter '85, Portsmouth; T. G. Wakefield '86, Roseville.

Another of our trustees has been called from the land of the living. The Hon. Horace Wilson, a member of the Board since '53, died at his residence in Columbus on the 18th of October. The deceased was born in Athens, Sept. 24, 1823. He was for some years a student in the University and though he never regularly completed a course of study he received the Degree of A. B. in 1855. In 1847 he began the practice of law. He served four years as a member of the Columbus Board of Education and the same length of time as a member of the city council. In 1881--2 he represented the counties of Franklin and Pickaway in the Ohio Senate, He was prominently identified with a number of city and State organizations. He was for several years President of the Ohio Forestry Bureau, and a life-long member of the Presbyterian Church. In politics he was an ardent Democrat.

Early in the fall term there were received between three and four hundred specimens of cryptograms from Professor W. A. Kellerman of the State University, at Columbus. These, together with the Calkins' collection of lichens, and the fungi and myxomycetes collected by Professor Chapin, will make a good working herbarium for advanced Botany.

We have received the course of study of the Norwich (N. Y.) Institute, a neatly printed pamphlet of about fifty pages. The school is in charge of L. W. Hoffman, 89, and is in a highly flourishing condition. Mr. Hoffman is supported by eight assistants. The institution prepares candidates for admission to the best colleges or for a business career. It has the reputation of being one of the best preparatory schools in the State.

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HENRY E. CHAPIN, M. SC.,	Professor of Biology and Geology.
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WALKER BOWMAN, A. M., PH. D.,	Professor of Chemistry.
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CHARLES M. COPELAND,	Instructor in Commercial Branches.
MABEL K. BROWN, B. PH.,	Instructor in Stenography and Typewriting.
CATHARINE S. BURNS, A. M.,	Assistant in English Literature and Rhetoric.
JOHN A. SHOTT, B. PED.,	Holder of Scholarship in Psychology.

The regular tuition is $30 per year, or $10 per term. This includes the contingent fee of $3. There is one free scholarship for each county in Ohio. All students pay the contingent fee whether they have a free scholarship or not. The following are not included in the above. Piano or voice training, two lessons per week, per term $10. Bookkeeping and allied branches $5 per term. Stenography and typewriting $5 per term. There is an additional fee for those who use the college pianos, and a small laboratory fee for those who take more than two terms of chemistry.